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Hearing on China's Offensive Missile Forces
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1. Drivers of China's Conventional Missile Forces

A combination of political, economic, and security factors has driven China's ambitious program of acquiring offensive missiles. Beijing's political leadership surely absorbed important lessons from the Taiwan Straits crisis of 1995-96, when China, in response to Taiwan's independence predilections, launched a highly orchestrated series of missile tests off the coast of Taiwan. While the Clinton administration responded by deploying with two aircraft carrier battle groups, China arguably succeeded in coercing Taiwan to tone down its rhetoric in regard to its wish to achieve independence from China.[2] If nothing else, the 1995-96 crisis managed to convince both Beijing and Washington that a war over Taiwan was by no means far-fetched. And in the aftermath of the U.S.-China confrontation over Taiwan, Beijing's political leadership saw fit to support the huge growth in the People's Liberation Army's arsenal of ballistic missiles facing Taiwan over the next decade. In short-range ballistic missiles (SRBMs) alone, China's Second Artillery's holdings grew from roughly 350 in 2003 to 1,100 today.

Clearly, China's conventional missile buildup has benefited from nearly double-digit annual increases in the defense budget over the last two decades. This comes as defense spending in the United States inevitably declines in the aftermath of fighting two wars in Iraq and Afghanistan since 2001. Yet, China faces a number of economic uncertainties that could adversely affect the level of support for defense spending. As China specialist Andrew Erickson argued before this body in January 2014, "The economic model that propelled China through three decades of meteoric growth appears unsustainable."[3]

Large structural factors lie at the heart of China's economic challenges, including dealing with access to clean water, remuneration costs related to environmental degradation, rampant corruption, potential divisiveness between urban and rural populations, and ethnic and religious unrest. Making matters worse are continued growth in chronic diseases coupled with the inevitable demographic changes China faces stemming from its one-child policy. Combined, these latter two developments will place stiff demands on China to cope with an aging population and a substantially diminished younger age cohort. In the end, how China addresses slower growth, rising financial demands, and internal security challenges, which have already elevated the cost of internal security to exceed that of defense spending, will ultimately shape Beijing's success in achieving military modernization on a par with the threats China faces.[4]

A third and potent factor driving China's rapid development of its conventional missile capabilities and forces bears on the PLA's security perceptions. Not having experienced a war since its brief military engagement with Vietnam in 1979, China has studied closely and extracted key lessons from America's success in the First Gulf War against Iraq, NATO's 1999 war with Serbia over Kosovo, and the PLA's presumed appreciation of the role missiles played in the Soviet-era air operation.

The First Gulf War of 1991 demonstrated the extent to which the U.S. military not only greatly exceeded the military capacity of Iraq but also of any other conceivable adversary it was likely to face. And such military capabilities, left unchecked, were destined to only grow if the U.S. military remained on course to pursue the essential elements of a true "Revolution in Military Affairs." The truth is that the 1991 Gulf War only dimly reflected signs of revolutionary changes in warfare. Virtually all the weapons used, however effective, were decades old. Nor were there any dramatic doctrinal, operational, or organizational innovations demonstrated. Nevertheless, what China surely took note of was evidence of revolutionary increases in effectiveness in the area of long-range precision strikes. Post-war analyses demonstrated that although comparatively few—on the order of 10 percent— precision-guided munitions (PGMs) were used, compared to "dumb" (meaning unguided) bombs, according to the post-war Air Power Survey, the target/sortie ratio in representative sorties for both PGMs and unguided bombs showed a 13:1 advantage for the precision case versus the non-precision one.[5] As a result, during the bombing of Yugoslavia in 1999, 30 percent of the bombs used were PGMs, while that figure grew to nearly 70 percent during the Afghan air campaign in 2001 according to press reporting.[6]

Despite the modest evidence of truly revolutionary advances by the U.S. military, the PLA's reading of events in the First Gulf War implied a huge gap between China's military capabilities and U.S. military advances evidenced in the swift defeat of Saddam Hussein's army. As Aaron Friedberg reports, "China now needed to prepare not only for 'limited, local wars,' but also for 'local wars under high-technology conditions.'" The clear message that China took away from the First Gulf War was the necessity to find ways for the "weak to defeat the strong."[7]

Supported by the achievement of information dominance, and by taking full advantage of its ability to dominate the reconnaissance battle at the outset of any war along its own periphery, Chinese planners recognized the critically important role ballistic and cruise missiles could play, particularly when they are employed preemptively.[8]

During the mid- to late 1970s, as China was just beginning to extract itself from the devastation of Mao's decade-long Cultural Revolution, the Soviet Union's military planners were reorganizing their air and air defense forces to provide greater flexibility in employing long-range strike aircraft, close-air support, and air defense of the ground forces. The goal was to refine the air operation so as it could become a substitute for the initial mass nuclear strike that was then the dominant Soviet way to begin a war with NATO. They also began improvements in ground force operations, logistics, command and control, mobility, and firepower. The focus of attention was on what they believed were the new conditions of warfare, principally including surprise and preemptive conventional operations. While the operational objectives and component parts of such preemptive operations were simple to conceive, they were complex to execute, especially compared with nuclear operations. And warfare being a two-sided phenomenon, any new emphasis on achieving conventional success would always be subject to the risk of nuclear escalation. Yet, such an ambitious objective would require a new conventional role for missile delivery systems, which had previously been largely a means of nuclear delivery.[9]

Key elements of the Soviet air operation can be seen in the synergy on display in the way China's dependence on missiles interacts with air operations.[10] In effect, missiles leverage the effectiveness of air power. Before missiles were sufficiently accurate to achieve success conventionally, the bulk of any preemptive first strike would have to be achieved using aircraft, which risked the loss of tactical surprise that much faster ballistic missiles would achieve. Aircraft would have to fly low-altitude missions to destroy enemy air defenses and thus become more vulnerable to enemy anti-aircraft missiles and guns. Most important, the desired shock and paralytic effect from aircraft alone would be greatly diminished by the demands of first taking out enemy air defenses.

Thus, the role of precursor ballistic and cruise missiles became the achievement of tactical surprise by catching most enemy aircraft on the ground. Aircraft released from having to achieve this paralytic blow could then fly higher altitude missions secure in the knowledge that fewer enemy air defense interceptors would meet them along the way to their targets. Before ballistic and cruise missiles were accurate enough to carry out this leveraging effect, they were seen as disadvantaged compared to aircraft, which on average can carry seven times the payload of a missile. Yet, the role that accurate missiles began to play due to their speed and probability of achieving paralytic effects enables previously more vulnerable aircraft to fully exploit their capacity on average to deliver seven times the payload of missiles.

2. The Intended Roles of China's Missiles in Conflict Scenarios

The primary mission that Chinese planners foresee for ballistic and cruise missile to execute is in support of a Taiwan scenario. They anticipate that such missile attacks would achieve the rapid if only perhaps temporary but critically important closure of Taiwan's airfields. Missile strikes against enemy airfield runways (primarily ballistic missiles), airbase command and control, early warning radar facilities, and ground-based air and missile defenses are valuable in order to enhance Chinese aircraft effectiveness. With Taiwan's air force largely prevented from—however temporarily—taking to the skies, Chinese aircraft could be released from air defense suppression responsibilities, allowing them to fly higher and deeper routes with heavier payloads and concentrate on reducing Taiwan's air sorties to a minimum. Chinese strategists see missile strikes against airbase runways and taxiways as designed, as Mark Stokes reports, to "shock and paralyze air defense systems to allow a window of opportunity for follow-on [Chinese air force] strikes and rapid achievement of air superiority."[11]

Shock and paralysis come from a high volume of accurate fire occurring in a brief timeframe. This concept explains the rapid growth of the PLA Second Artillery as well as qualitative improvements in the People's Liberation Army Air Force (PLAAF) attack capabilities. China's short-range ballistic missile (SRBM) force grew from a single regimental-size unit to seven brigades by 2008, including five controlled by the Second Artillery and two directly subordinate to PLA ground forces, one in the Nanjing Military Region (MR), and another in the Guangzhou MR. This configuration may have changed more recently, according to Mark Stokes. In his April 2011 assessment he reports, "There are indications that two tactical missile brigades under the PLA Army have transferred to the Second Artillery."[12] By December 2010, China's arsenal consisted of 1,000 to 1,200 solid propellant, road-mobile SRBMs, all deployed opposite Taiwan. According to the Department of Defense's China Military Report for 2010, this includes 350-400 CSS-6 SRBMs (with 90-110 launchers) and 700-750 CSS-7 SRBMs (with 120-140 launchers). More recently, a Taiwanese media report cites the Taiwan Ministry of National Defense "China Military Power Report 2012" as claiming that the number of Second Artillery ballistic and land-attack cruise missiles (LACMs) aimed at Taiwan has increased from 1,400 in 2011 to 1,600 in 2012. And an increasing number of these missiles are outfitted with GPS to achieve precision effects. DF-16 medium-range ballistic missiles (MRBMs) have also been deployed in small numbers.[13]

As for LACMs, the 2009 DOD China Military Report estimates that by December 2009 China had deployed 200-500 DH-10 LACMs and 45-55 launchers.[14] In addition, an uncertain number of YJ-63 LACMs (two per H-6H medium-range bomber and possible some 3M-14E submarine-launched LACMs on kilo-class submarines) could figure into a campaign. The DH-10 is reported to be highly accurate; Jane's reports that it has a10m circular error probable (CEP) accuracy.[15]

Missile launchers are included as a critical variable of effectiveness because they, not just the total number of missiles, define the intensity of fire within a particular unit of time during a campaign. This would be the case if missiles were employed to pin down Taiwan aircraft on their airfields, thereby preventing them from taking off to meet Chinese aircraft in air battles. These numbers interact sharply with the way in which Taiwan concentrates its primary aircraft at three of eight major airbases.[16] Taiwan does park some of its aircraft in hardened shelters, and a small strategic reserve of aircraft is hidden in hardened mountain bunkers. The number of China's short-range ballistic missile launchers (200-250), complemented by DH-10 LACM launchers (40-55 and presumably growing), permits intense pulses of conventional firepower against not only airfields but also other critical target sets, such as air and missile defense sites, early warning radars, command and control facilities, and logistical storage sites. LACMs, because they are more accurate than ballistic missiles, would likely be earmarked to take out point targets such as airfield hangers, command and control facilities, and logistic facilities, while ballistic missiles would likely deal with area targets, including airfield runways and taxiways. In addition to their precision quality, the virtue of LACMs is also reflected in their capacity to approach the targets from 360-degree angles of attack flying at low altitudes toward the target—an operational advantage that Taiwan's strategists both understand and fear.[17]

This section has concentrated on China's newfound interest in and deployment of LACMs, which, as argued here, play a critically important role in attack scenarios against Taiwan's airbases and other critical military facilities. Over a much longer period of time, China has also substantially increased its holdings of anti-ship cruise missiles (ASCMs) for attacks primarily against enemy ships at sea. For example, rather than depending largely on foreign suppliers, China has developed its own highly capable ASCMs (the YJ series). Yet, the most worrisome ASCM acquisition is Russia's Sunburn and Moskit supersonic ASCMs with ranges of 120 and 240 km, respectively. Virtually every new surface ship and conventionally powered submarine in the PLA Navy (PLAN) can launch ASCMs, allowing these platforms to serve as "aquatic TELs" (Transporter-Erecter-Launchers).[18] Still, even though training has improved in recent years and improved guidance systems have become available to the PLAN's ASCMs, over-the-horizon targeting remains a challenge.

China possesses far more ASCMs than the U.S. Pacific Fleet would employ. Hypothetically speaking, for a Taiwan scenario, a typical U.S. Carrier Strike Group (CSG) might sail with three or four ASCM-capable combatants. Assuming that only a third of the PLAN surface combatant fleet would be operating in support of such a scenario against one U.S. CSG, the ratio of ASCMs on the battlefield would be at least 7:1 in favor of the PLAN. This ratio does not include the number of air and (in China's case) submarine-launched ASCMs that might be massed during such an engagement. Factors such as weapon system readiness, reliability, load-out, firing policy, and ASCM effectiveness during saturation attacks are also not considered here. This is not to say that these factors would not influence the outcome of the ASCM battle, of course. In any event, assuming that both PLAN and U.S. forces would apply maximum available combat power, it is difficult to imagine a situation in which a lone U.S. CSG could flip the ASCM ratio in its favor.

To be sure, this is not the only relevant metric or comparison. It is not just a question of the ASCM ratios but also of the ability to move platforms that shoot ASCMs into range of their targets. It is not so much who has more ASCMs as who can fire them at the other side first. If one side has so many they literally do not need to target, then having more than the other is helpful. If not, then it may be irrelevant. If there are significant terminal defenses, that also might make overall inventories important, although it would be a case of one's side inventory versus the other side's defense, not a straight-on ratio of inventories.

It is important to keep in mind that the United States could use air and undersea platforms to target PLAN ships that get too far out from their air defense cover. Still, China's increasing ability to concentrate ASCM fires will have important implications for where the United States can and should employ CSGs. This may explain the U.S. Navy's apparent interest in electromagnetic rail guns.[19]

3. Assessment of China's Current Missile Capabilities

China has invested considerable resources both in acquiring foreign missiles and technology and in developing its own missile capabilities. These efforts are bearing fruit in the form of relatively advanced ballistic missiles and ASCMs and LACMs deployed on a wide range of platforms. To realize the full benefits, China will require additional investments in all the relevant enabling technologies and systems to optimize missile performance. Shortcomings remain in intelligence support, command and control, platform stealth and survivability, and post-attack damage assessment, all of which are crucial to missile success.

ASCMs and LACMs have significantly improved PLA combat capabilities and are key components in China's efforts to develop Antiaccess/area denial (A2/AD) capabilities that could increase the costs and risks for U.S. forces to operate near China, including in a Taiwan contingency. China plans to employ cruise missiles—especially LACMs—in ways that exploit synergies with other strike systems, including using LACMs to degrade air defense and command and control facilities to enable follow-on air strikes. Defenses and other responses to China's LACMs are minimal at best and a more focused effort is needed to develop technical countermeasures and effective operational responses.

The addition of both LACMs and growing number of ASCMs on multiple platforms begs the question of China's true ability to employ these weapons to maximum advantage. This depends on a multitude of factors, three of which bear mentioning.

A key question is whether China possesses the C4ISR (command, control, communications, computers, intelligence, surveillance, and reconnaissance) capabilities to fully exploit these growing missile capabilities. The challenge of carefully orchestrating a complex, multifaceted air and missile campaign over many days depends on both human and technical factors—extremely well-trained military personnel who have practiced these routines in diverse ways over many years and the command and control architecture needed to deal with complex combined-arms operations involving multiple service organizations. Chinese planners envision establishing a Firepower Coordination Center (FCC) within the Joint Theater Command, which would manage the application of air and missile firepower. Separate coordination cells would be created to deal with missile strikes, air strikes, special operations, and ground and naval forces. Absolutely critical to achieving the delicate timing between waves of missile strikes designed to leverage the effectiveness of subsequent aircraft attacks is developing the skill to coordinate and de-conflict large salvoes of missiles and waves of aircraft operating in multiple sectors. It is doubtful that China could execute such a complex joint campaign with any degree of confidence.

In principle, the first wave of any air operation should be the easiest to execute, particularly if China manages to strike first, before critical targets such as aircraft have departed their airbases. But it is still a daunting execution task. Once the war begins chaos and complexity commence. It is commonplace to underestimate C4ISR, which the Chinese have only recently begun to take seriously from a joint-force standpoint. As retired U.S. Navy Captain Wayne P. Hughes argues in his classic book *Fleet Tactics: Theory and Practice,* "The art of concentrating offensive and defensive power being complicated, it is easy to exaggerate the potential of the enemy to master it."[20] Consider the added complexity of achieving mastery of C4ISR in the multi-service context of joint, not just naval operations.

Since the late 1990s, the PLA has undertaken large-scale exercises and more recently begun to work on joint operations. Still, John Lewis and Xue Litai quote a PLA officer speaking candidly about such large-scale Chinese exercises: "The exercise is part of the PLA's annual training, but its political significance is greater than its military significance."[21]

Proficiency with even the use of one particular weapon system is not achieved without lengthy mastery, and not just in peacetime exercises or under peacetime test conditions but during actual combat operations—something China hasn't faced since 1979. Take, for example, the U.S. Navy's successful use of Tomahawk LACMs. Conventional wisdom has it that the revolution in information technology easily enables the precision delivery of conventional payloads over great distances in the form of LACMs aided by advances in global positioning system (GPS) technology. To be sure, the advent of GPS has contributed to the proliferation of LACMs over the last decade. Yet, the process of becoming truly proficient requires more than access to technology. What is unique about today's Tomahawk LACM, even the latest Block IV version, is the extent to which its performance has benefited from years of feedback from system diagnostics collected ever since the Tomahawk was first tested and later deployed in the 1970s. Most Tomahawks, in peace and war, have been analyzed to determine as precisely as possible what accounted for the missile's performance, good or bad. To learn from such successes and errors requires that missile specialists have the kind of sophisticated diagnostic equipment and system engineering skills that provide hints about system performance. Armed with such important knowledge about Tomahawk performance, it is no surprise that current versions of the missile greatly exceed the Tomahawk's progenitor.[22]

While China will probably not require decades to develop high confidence in LACM performance, it will require time and dedicated effort before it can expect that its LACMs will perform as desired, particularly in combined arms campaigns and especially in the absence of real-war experience.

Quantitative and qualitative capabilities of China's current missile programs will naturally adjust in accord with threat perceptions. Given their precision accuracy and important role in targeting critical target sets, one would expect growth in LACM holdings to continue in the near term and expand over the longer term to include China's own development of supersonic ASCMs and LACMs. Indications exist that an antiship variant of the DH-10 LACM with a range of 3,000km could be in the early phase of an R&D program, however much the targeting demands present stiff technological challenges. The success of all of these developments hinges on not only achieving technological breakthroughs but also China's success in coping with the stiff political, societal, and environmental demands briefly outlined in section 1 of my testimony.

4. Prospects for the Dongfeng-21D Carrier Killer

China faces stiff challenges in several needed components of its Dongfeng-21D carrier killer to transform it into a potent weapon system. Obviously, peacetime tests against land targets do not equate to finding the target carrier in the open ocean, maintaining continuous target tracking from a survivable target tracking system, reaching the intended carrier having penetrated the U.S. Navy's defensive means, and finally achieving disabling damage to the carrier.

Thus far, China seems to have placed most emphasis on improving its over-the-horizon radars. If they have found a solution to improving the resolution of such a system that it might differentiate a carrier from other large seaborne objects, that would be an important achievement. Nevertheless, the fact that OTH radars are fixed systems makes them immensely vulnerable in wartime. A less vulnerable option would be airborne or space-based radars; the U.S. Joint Stars or Global Hawk radar systems furnish an example of the former. But even these systems possess only a limited viewing field at the altitude they achieve. In principal, a more ideal altitude is to operate a large airship at near-space, between 65,000 and 328,000 feet altitude, something the Chinese appear to be investigating, as have other countries, including the United States. The most important weaknesses of near-space platforms (usually large helium-filled balloons) are that they provide large cross sections that can be affected by winds and turbulence during inflation, and particularly when they are launched and ascend into place in near space. The U.S. Army JLENS aerostat has experienced launch problems from high winds even at very low altitudes. Large constellations of electro-optical or radar sensors operating in low-earth orbits would in principle represent the best solution. In the late 1990s, the Pentagon's Defense Research Projects Agency proposed building a 24-48 constellation of radar satellites that could have, in principle (it was not funded), furnished near continuous coverage from a low-earth orbit, and conceivably could have evolved into a tracking system. Yet, the expense of such a large constellation, particularly one the size of which would furnish truly continuous coverage with high accuracy from low-earth orbit, would be exceptionally costly and technologically demanding. And assuming such a system were possible, its downlinks and component spacecraft could be subject to attack.

Another uncertainty is whether or not China has truly mastered the terminal guidance and maneuvering capability needed to successfully attack a moving aircraft carrier. Particularly demanding are the development of sensors and warheads that can survive the rigors of atmospheric reentry, including high speeds and temperatures—without adversely affecting required seeker and warhead performance. This endgame phase must also consider the defenses that China will face in attacking such a high priority target. To be sure, if the DF-21D approaches its target from a depressed trajectory and undergoes maneuvering before attacking, it will stress navy defensive systems. Still, the U.S. Navy has invested heavily in two transformative programs that have greatly improved defense of carriers. They include the E2-D's new AESA radar and an entirely new avionics system, and the introduction of a cooperative engagement capability, which effectively creates a single integrated operational picture by virtue of melding together all navy air defense sensors into a common picture. Thus, every shooter sees the same picture as all others, thus optimizing prospects for the highest probability interception.

Finally, it is also important to keep in mind just how robust navy carriers are. The USS Enterprise suffered a catastrophic accident at sea in 1969, in which nine 500-pound bombs exploded killing 27 sailors and injuring 300 others. Were it wartime, the carrier could have resumed operations within hours. Every new carrier entering the fleet undergoes new safety and damage control improvements.[23] To be sure, a successful DF-21D strike in the right place on a carrier could produce devastating results, but such resilience should be kept in mind.

5. China's Hypersonic Glide Vehicles

China's interest in hypersonic glide vehicles is probably driven by a desire to keep pace with U.S. interest in the technology as well as the potential role these systems could play in warfare if they were successfully developed. In the latter regard, Chinese planners undoubtedly see great virtue to difficulties that hypersonic glide vehicles would create for existing U.S. missile defense systems. Difficulties would emerge because of the nature of boost-glide vehicles compared with ballistic missiles for missile defense detection and subsequent intercept. Ballistic missiles, as the name implies, fly on a ballistic or high arcing trajectory before returning to the target. They are therefore in principle comparatively easier to detect in mid-course than hypersonic glide vehicles, which are boosted into space but then travel on a generally flat trajectory in the stratosphere to their intended targets. This makes them more difficult targets to track, at least with today's missile defense systems.

The United States appears ahead of China in developing both hypersonic glide vehicles and scramjet-enabled hypersonic cruise missiles. The Boeing X-51WaveRider hypersonic cruise vehicle failed its first two tests and then achieved a flight of over 6 minutes with a speed of around Mach 5 in 2010. The Hypersonic Test Vehicle, funded by the Defense Advanced Research Projects Agency, has achieved only minimal success (briefly achieving Mach 20), while the U.S. Army's Advanced Hypersonic Weapon has one successful flight and one test failure. The Chinese WU-14 succeeded in early January 2014 with its maiden flight test but failed in its second attempt in August 2014.

China also appears ready to investigate scramjet technology, which makes sense for reasons that both the United States and Russia have done so, albeit with very modest success. Technical reasons for China to do so probably include the extremely high speeds (Mach 12 to 24 in theory) these vehicles could conceivably achieve. In July 2014 a press report disclosed that a technical journal in China had reported on research related to a hypersonic cruise missile. The journal included a line drawing of vehicle appearing to be a copy of NASA's X-43 scramjet test vehicle.[24] The extent to which China has achieved anything beyond copycatting to demonstrate interest or intention remains to be seen. At the moment, neither the United States nor China appears close to deploying either hypersonic glide vehicles or hypersonic (scramjet aided) cruise missiles.

When discussing (especially) scramjet-aided cruise missiles and even hypersonic glide vehicles, it is useful to recall the past efforts in pursuit of developing similar systems. Hypersonic cruise missiles would be expected to take off and land from runways and be anywhere around the world in one to two hours. The idea for such a space plane has been around since the 1950s.[25] President Ronald Reagan accelerated the push in his 1986 State of the Union Address to Congress, yet his director of the Strategic Defense Initiative, Henry Cooper, told a congressional panel in 2001 that after the expenditure of some $4 billion on the development of the space plane concept from the early 1970s to the end of the 1990s, the only thing produced was "one crashed vehicle, a hangar queen, some drop-test articles and static displays."[26] Both the United States and China face extremely stiff challenges in dealing with engine system dynamics, development of advanced lightweight high-temperature materials, and appropriate cooling technologies to cope with an extremely stressing aerothermal environment.[27]

6. The Prospects of Sea-Based Land-Attack Cruise Missiles

The likelihood that China will develop and deploy LACMs on ships or submarines is high over time. The chief reason why was captured succinctly by strategist Albert Wohlstetter in September 1994, much before the widespread proliferation of sea-based LACMs had begun:

> "They might be launched from concealed land locations at modest distances from their targets; or brought within range and launched from freighters, diesel or nuclear-propelled submarines or other boats so numerous and so varied that they would be hard to distinguish and track. Such 'two stage' delivery of cruise missiles could present a threat here at home as well as threats to our forces or allied forces or civilians abroad. Moreover, they might be part of a serious but isolated terrorist threat, or they might be one important component of a widespread military attack."[28]

The multiplicity of launch options will support strong Chinese incentives to investigate and eventually implement LACM launch options from surface ships and submarines, notwithstanding the comparative advantages that the U.S. Navy possesses in undersea warfare. Ground-launched LACMs will remain a strong competitor; while they do not offer the multitude of options Wohlstetter speculated about, they remain highly survivable due to their mobility and the inherent challenges of detecting and executing attacks against highly mobile missiles moving and hiding over China's land-mass. Perhaps the most important impact that China would achieve by pursuing sea-based LACM launch options would be broadening the overall reach of their LACM strike options that would eventually come from gaining experience in undersea warfare. A timeframe of five to ten years would seem a reasonable estimate, assuming serious attention is paid to achieving undersea and surface-based operational proficiency.

7. Short-Range Ballistic Missile Buildup

My assessment of the buildup of China's ballistic missiles facing Taiwan is addressed in section 2 of my testimony. A few additional comments amplifying on this threat are in order. First, Taiwan's deployment of Patriot missile defenses in the 1990s focused on protecting three population centers rather than air bases, no doubt for political reasons. This left air bases highly vulnerable to Chinese ballistic and especially LACM threats.[29] Taiwan's more recent purchases of Patriot missiles, once they are fully deployed by mid-decade, would conceivably provide some minimal degree of protection, and thus deterrent value, for Taiwan's air force.[30] Taiwan has also invested $1.4 billion in its Surveillance Radar Program (SRP), which is designed to provide early warning against both ballistic and cruise missiles. That investment will only manage to improve Taiwan's missile defense program if China decides not the attack the highly vulnerable SRP ground-based large phased array radar, which frankly is inconceivable were war to break out between China and Taiwan. There are claims also that China's new phased array radar can readily jam the SRP.[31] Taiwan could still depend, however less effectively, on its Patriot battery's ground-based radar to provide support for intercepting ballistic missile threats, but far less so for low-flying LACMs due to the limitations that ground-based radars face when confronting such threats. Simply put, without a more survivable airborne platform or less preferably a more vulnerable aerostat providing support to ground-based Patriot interceptors, Chinese LACMs will have a relatively free ride to their intended targets.[32]

8. Technological Inputs for China's Missile Developments

There is little question that China has needed to look for significant outside sources of know-how in fashioning its military-technical approach to missile development, particularly with regard to LACMs. China's long-term quest is to build a wholly indigenous defense industrial base that would benefit greatly from joint ventures in the civilian sector, an ever-growing body of intellectual capital derived from students studying abroad in the best engineering universities, and extensive military and civilian efforts at industrial espionage. Russia and, to a lesser extent, Israel, Ukraine, and Belarus have satisfied near-term requirements for weapon systems, technology, and specialized know-how. After the end of the Cold War, Russia and China's needs converged. China sought the most advanced technology it could acquire. Russian defense industries, faced with disappearing state subsidies, found a convenient lifeline in foreign military sales. With Moscow's governance over such matters questionable at best, China made deals, including licensed production of the Su-27 fighter, that would never have occurred in former times.

Amid virtual chaos in the Russian defense sector, China reportedly obtained Russian consent to recruit a cruise missile research and development team.[33] Other unconfirmed sources in Taiwan also believe that China successfully recruited between 1,500 and 2,000 laid-off scientists and engineers and located them at a factory, named Xinxin, in Shanghai, where they work with Chinese missile specialists on intermediate-range cruise missiles, or "imitated versions of the Kh-55."[34] It remains doubtful that Russia provided

China with either the Kh-55 or its turbofan engine during this period. Had it done so, there would not have been compelling reasons for China to have illegally procured six Kh-55 LACMs in 2000 from Ukraine. But it does appear plausible that Russian personnel did furnish China with scientific and engineering know-how that advanced their LACM ambitions in the early to mid-1990s.

China routinely steals technology when targets of opportunity become available. A notable success is the acquisition of six Russian Kh-55 LACMs from Ukrainian and Russian sources. Reverse engineering, even with its shortcomings with respect to a complex system like a turbofan engine, should have proven valuable already. China's acquisition and subsequent exploitation of recovered Tomahawks kindly furnished by Pakistan has probably also helped, with perhaps some reciprocal benefit flowing back to Islamabad in the form of the Babur LACM, or at least components thereof.

And then there are failures, as when Ko-Suen "Bill" Moo, a Taiwanese national, who worked for American defense contractor Lockheed Martin in Taiwan, was caught in 2005 by U.S. Customs agents in a sting operation attempting illegally to export military items to China. Moo and a French national were charged by federal prosecutors with attempting to purchase an F-16 jet engine, cruise missiles, and air-to-air missiles for China. Moo provided an undercover Customs agent with documents showing specific Chinese interest in acquiring the AGM-129 LACM, which is capable of carrying a nuclear warhead to a range of 3,700km. Developed in the 1980s to penetrate thick Soviet air defenses, the AGM-129 is a highly advanced stealthy cruise missile that was originally slated to remain in the U.S. nuclear inventory until 2020 but is being retired early as part of U.S. nuclear reductions required under the Moscow Treaty of 2002. Moo had deposited $3.9 million in a Swiss bank account to purchase the weapons and, in a final meeting with Customs agents to discuss exporting the F-16 engine to an airport in China, Moo wired $140,000 for shipping fees to a Miami bank account. Moo pleaded guilty in May 2006 to acting as a covert agent for the Chinese government.

9. Sophistication of Chinese Production Processes

To compensate for weaknesses in its indigenous production processes, China has embraced a multi-pronged strategy centered on exploiting joint ventures with foreign companies to acquire critically needed know-how. With the liberalization of export controls on dual-use products and technologies that occurred at the end of the Cold War, China accelerated efforts to acquire production processes for U.S. jet engines. In 1996, for example, Pratt and Whitney Canada, a subsidiary of U.S.-based United Technologies, established a joint venture with China's Chengdu Engine Company to manufacture aviation parts. Chengdu not only manufactures components used in Boeing aircraft, but also for the PLA Air Force's WP-13 turbojet engine that powers the F-8 fighter.[35] This is one among many U.S.-Chinese joint ventures in areas where China could conceivably gain valuable production processing knowledge by working with top-notch U.S. engines manufacturers. Other prominent examples include a 2003 joint venture between General Electric and

Shanyang Liming Aero Engine Corporation to co-produce the CF034-10A jet engine for one of China's regional jets and the much more direct acquisition of Russian know-how to assist China's development of the WS-10A turbofan engine for China's J-10 and J-11 version of the co-produced Su-27.

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[1] My testimony draws in part on Dennis M. Gormley, Andrew S. Erickson, and Jingdong Yuan, *A Low Visibility Force Multiplier: Assessing China's Cruise Missile Ambitions* (Washington, DC: NDU Press, 2014), http://ndupress.ndu.edu/Portals/68/Documents/Books/force-multiplier.pdf and Dennis M. Gormley, *Missile Contagion: Cruise Missile Proliferation and the Threat to International Security* (Annapolis: Naval Institute Press, 2010).

[2] For an analysis of the Taiwan Strait crisis as a case of coercive diplomacy, see Andrew Scobell, "Show of Force: The PLA and the 1995-1996 Taiwan Strait Crisis," Working Paper, Shorenstein APARC, January 1999.

[3] Andrew S. Erickson, "Testimony Before the U.S.-China Economic and Security Review Commission, Hearing on China's Military Modernization and its Implications for the United States," January 30, 2014.

[4] "China's Spending on Internal Policing Outstrips Defense Budget," *Bloomberg Business*, March 6, 2011, http://www.bloomberg.com/news/articles/2011-03-06/china-s-spending-on-internal-police-force-in-2010-outstrips-defense-budget.

[5] Thomas A. Keaney and Eliot A. Cohen, *Gulf War Air Power Survey, Summary Report* (Washington, DC: US Government Printing Office, 1993), pp. 242-244.

[6] Scott Peterson, "'Smarter' bombs still hit civilians," *Christian Science Monitor,* October 22, 2002, http://www.csmonitor.com/2002/1022/p01s01-wosc.html.

[7] Aaron L. Friedberg, *Beyond Air-Sea Battle: The Debate Over US Military Strategy in Asia* (Abingdon, Oxon: Routledge for IISS, 2014), p. 17.

[8] On the critical role that information dominance plays in Chinese doctrinal deliberations, see Mark A. Stokes, *China's Strategic Modernization: Implications for the United States* (Carlisle, PA: Strategic Studies Institute, 1999), chapter 3, http://fas.org/nuke/guide/china/doctrine/chinamod.pdf.

[9] When Mark Stokes reports about Chinese planners focusing on missile strikes to achieve "shock and paralysis," it sounds very similar to what students were taught at the Soviet-era Voroshilov General Staff Academy. There students were taught "success in air operations is ensured by delivering surprise mass initial strikes on enemy airfields." See Gormley, et. al., *A Low Visibility Force Multiplier,* endnote 6, p. 154. The Voroshilov General Staff Academy lectures acquired by the U.S. intelligence community in the 1980s and subsequently declassified and released. They are available through the Defense Technical Information Center. On what the Chinese might have learned from their Soviet brethren, see Xiaobing Li, *A History of the Modern Chinese Army* (Lexington: University of Kentucky Press, 2009).

[10] On the leveraging effects of missiles in support of an air operation, see Dennis M. Gormley, *Double Zero and Soviet Military Strategy: Implications for Western Security* (London: Jane's Publishing Co., 1988).

[11] Mark A. Stokes, "The Chinese Joint Aerospace Campaign Strategy, Doctrine, and Force Modernization," in *China's Revolution in Doctrinal Affairs,* ed. James Mulvenon and Daniel Finkelstein (Alexandria, VA: CNAC Corporation, 2005).

[12] Mark A. Stokes, "Expansion of China's Ballistic Missile Infrastructure Opposite Taiwan," *AsiaEye*, April 18, 2011, http://blog.project2049.net/2011/04/expansion-of-chinas-ballistic-missile.html.

[13] Rich Chang and J. Michael Cole, "China aiming 200 more missile at Taiwan: MND," *Taipei Times*, September 4, 2012, www.taipeitimes.com/News/front/archives/2012/09/04/2003541913.

[14] Detecting ballistic missiles is more likely to be the case than for LACMs, which are easier to hide and unlike for ballistic missiles during their development, LACMs do not involve the testing of large rocket motors that are more readily detectable by U.S. technical collection means.

[15] CEP is a measure of a missile's accuracy in which the radius within which 50% of the missiles land.

[16] According to "Taiwan—Air Force," *Jane's World Air Forces*, March 1, 2013, all Taiwan's Mirage 2000 air-defense aircraft (roughly 60) are housed at Hsinchu Air Base, while two other bases (Chiayi and Hualien) support around 120 F-16 air-defense/attack aircraft.

[17] Interview with a senior Taiwan official, April 2008, Monterey, CA. Targets vulnerable to LACMs but not SRBMs include aircraft housed in mountain revetments with doors at the base of the mountain. The most vulnerable aim point for a hardened shelter is the shelter door. Low-flying LACMs are worrisome

because of their angle of attack and accuracy; even if they fail to penetrate the door, striking it would probably collapse it sufficiently to delay departure of aircraft, leading to a temporary functional kill.

[18] William Murray, *China's Undersea Warfare: A USN Perspective* (Newport, RI: China Maritime Studies Institute, Naval War College, May 11, 2011).

[19] "Navy Wants Rail Guns to Fight Ballistic and Supersonic Missiles Says RFI," USNI News, http://news.usni.org/2015/01/05/navy-wants-rail-guns-fight-ballistic-supersonic-missiles-says-rfi.

[20] Wayne P. Hughes, *Fleet Tactics: Theory and Practice* (Suitland, MD: Naval Institute Press, 1986), p. 219.

[21] John Lewis and Xue Litai, *Imagined Enemies: China Prepares for Uncertain War* (Stanford: Stanford University Press, 2006), p. 261.

[22] Although data is sparse about Tomahawk's actual performance historically, Operation Desert Storm in 1991 saw Tomahawk's first used in combat, in which 317 missiles were employed. Tomahawk's performance in 1991 surely must have benefited from the fact that the system was tested repeatedly in peacetime for several years. Still, however much Tomahawk was tested and then used in 1991, there was still room for significant improvement, and that appears to have been the case in subsequent uses in actual combat operations. From the modest number (317 over three weeks of combat) employed in 1991, 420 Tomahawks were used in Operation Desert Fox (1998) in 4 days. In Operation Iraqi Freedom, that number jumped to 1,375 cruise missiles employed. There is public data for the U.S. Harpoon ASCM, which reportedly achieved a 50 percent reliability rate after 50 tests. See Gormley, *Missile Contagion*, chapter 6.

[23] Loren Thompson, "Aircraft Carrier (In)vulnerability," Naval Strike Forum, Lexington Institute, 2001.

[24] Bill Gertz, "Report Reveals Chinese Military Developing New Scramjet–Powered Hypersonic Missile," *Washington Free Beacon*, July 10, 2014, http://defence.pk/threads/report-reveals-chinese-military-developing-new-scramjet-powered-hypersonic-missile.323220/.

[25] The first publicly acknowledged program, in 1957, was the U.S. Air X-20 Dyna-Sour, which was supposed to be launched vertically off the ground and then glided back to earth for landing. The current hypersonic cruise vehicle would be expected to operate between 30 to 50km altitude.

[26] Testimony of Henry F. Cooper to the House Subcommittee on Space and Aeronautics Committee on Science, October 11, 2001. Cooper largely placed blame on Pentagon management inefficiencies for the program abysmal performance.

[27] For an American view on such hypersonic challenges, see David M. Van Wie, Stephen M. D'Alessio, and Michael E. White, "Hypersonic Airbreathing Propulsion," *Johns Hopkins APL Technical Digest* 26, no. 4 (2005), pp. 430-436.

[28] Foreword to K. Scott McMahon and Dennis M. Gormley, *Controlling the Spread of Land-Attack Cruise Missiles* (Marina del Rey, CA: American Institute for Strategic Cooperation, 1995),

[29] This is because Patriot's ground-based radars have horizon limitations against low-flying threats such as LACMs. This was demonstrated during the initial phase of Operation Iraqi Freedom in 2003 when Iraq's surprise use of cruise missiles went undetected but contributed to several friendly fire incidents. See Gormley, *Missile Contagion*, chapter 7.

[30] On Taiwan's missile defenses, see Ed Ross, "Taiwan's Ballistic-Missile Deterrence and Defense Capabilities," *Chief Brief* 11, no. 3 (February 10, 2011), http://www.jamestown.org/programs/chinabrief/single/?tx_ttnews%5Btt_news%5D=37489#.VQ2NAig2VjB.

[31] "Taiwan's early warning radar can be jammed by China," Asia-Pacific Perspective, http://ap-perspective.blogspot.com/2014/06/taiwans-early-warning-radar-can-be.html.

[32]For more details on the challenges of intercepting LACMs, see Gormley, *Missile Contagion*, pp. 163-174.

[33] Stephen J. Blank, *The Dynamics of Russian Weapon Sales to China* (Carlisle, PA, Strategic Studies Institute, 1997). Blank indicates that Chong-Pin Lin of the American Enterprise Institute in Washington, D.C. was the source of this information, which dates to August 1995.

[34] "Current Research and Development of Cruise Missiles in the PRC," *Taipei K'ungchun Hsueh-shu Yueh*, Issue no. 588 (internet version, in Chinese), February 27, 2006 (FBIS Translated).

[35] *U.S. National Security and Military/Commercial Concerns with the People's Republic of China,* Select Committee of the United States House of Representatives, 105th Congress, 2d Session, Report of the Select Committee on U.S. National Security, submitted by Mr. Cox of California, Chairman Report 105-85 (Washington, D.C.: U.S. Government Printing Office, January 3, 1999), chapter 10.